Geophysical Research Abstracts
Vol. 15, EGU2013-13147, 2013
EGU General Assembly 2013
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Border control! Capillary pressure / saturation relationships in a diphasic flow in a random medium: Influence of the boundary conditions

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Solving problems involving biphasic flows in porous media, at a scale larger than the pore one, normally requires the use of relationships between pressure and saturation. These allow the closure of generalized Darcy flow models for two phases, commonly used in hydrology or large scale problems of diphasic flow in porous media. There are mathematical models which approximate experimental records with curve-fitting equations. The two most common models are the Brooks-Corey and van Genüchten ones, they are used to complete a system of generalized Darcy equations.
The purpose of the current study is the influence of the boundary conditions on the relationship between pressure and saturation. We perform numerical simulations of drainage experiments. Water is the wetting fluid and air is the non wetting fluid. The results highlight the fact that a filter which allows only water to flow at the exit face of the system modifies both the shape of the curve and the value of the residual saturation. The pressure of the models that are commonly used does not match with the pressure of real flows since there is no filter to cross, to flow from an elementary volume to another.
Experiments performed in transparent Hele-Shaw cells exhibit the same features, showing the influence of the semi permeable boundary conditions on the pressure-saturation measures obtained. This effect corresponding to the formation of localized plugging clusters at the boundaries, is obtained in slow flow conditions, and is independent of any dynamic fingering, also known to affect such relations (1,2,3).

Modeling flows in open media thus would require to use the central part of the curves pressure saturation where the effect of the boundaries is the least important, or to modify properly these relationships to extract the behavior unaffected by boundaries.

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